Optimising lighting for older people: The challenges

Debra J. Skene

d.skene@surrey.ac.uk

Chronobiology
Faculty of Health and Medical Sciences
University of Surrey

ESRC New Dynamics of Ageing
Why light supplementation for older people?

- Our sleep changes as we age
- Sleep quality depends on the circadian timing system

![Diagram showing the relationship between light, eye, body clock, sleep, and body temperature.]

- Light is the major cue for the circadian clock
- **Blue light** is most effective at influencing sleep and the body clock
Why light supplementation for older people?

Older people have reduced light exposure

- age-related ocular changes reduce the amount of light perceived
Age-related changes in the eye

- The pupil size diminishes, reducing the amount of light that can enter the eye
- The lens grows larger and loses its ability to focus for near objects; it also yellows and darkens
- The ciliary muscle loses its power to control lens thickness
- The vitreous produces harmless floaters
- Lens transmission decreases
- S-cones and melanopsin RCGs decrease
- The sclera may yellow

Adapted from Weale, 1988
Age-related changes in the eye

increased lens density $\rightarrow$ reduced transmission of light

Lerman, 1980
Age-related changes in the lens reduce transmittance of short wavelength blue light.

Average spectral density of the lens (adapted from Pokorny et al., 1987)
Why light supplementation for older people?

Older people have reduced light exposure

- age-related ocular changes reduce the amount of light perceived
- reduced exposure to outdoor light (reduced mobility)
- homes are often poorly lit
Why blue light supplementation for older people?

Laboratory studies
• reduced responsiveness to short wavelength blue light
Why light supplementation for older people?

Older people have

- reduced light exposure
- require 3-5 times more light
Field studies

Effect of blue-enriched and control white light on sleep quality and daytime alertness in older people?

- in the community (WP5)
- in care homes (WP6)
Spectral composition

Blue-enriched white light
high colour temperature
17000 K

Control white light
low colour temperature
4000 K

Relative spectral power distribution

-100
0
100
200
300

17000 K lights
4000 K lights

Wavelength (nm)

Relative spectral power distribution

400 450 500 550 600 650 700

Wavelength (nm)
Aims

• To increase light levels and light exposure in older people

• To test if increasing light levels will affect sleep and mood

Hypothesis – effect of lights blue-enriched > control > original lighting
### Methods - assessment of sleep

**SLEEP DIARY**

- Subject code:…………………………….
- Date:……………………………………

<table>
<thead>
<tr>
<th>Question</th>
<th>Answer</th>
</tr>
</thead>
<tbody>
<tr>
<td>What time did you go to bed?</td>
<td></td>
</tr>
<tr>
<td>What time did you try starting to sleep at?</td>
<td></td>
</tr>
<tr>
<td>How long did it take you to fall asleep (mins)?</td>
<td></td>
</tr>
<tr>
<td>How many times did you wake up?</td>
<td></td>
</tr>
<tr>
<td>How long were you awake for? (mins)</td>
<td></td>
</tr>
<tr>
<td>What time did you wake up?</td>
<td></td>
</tr>
<tr>
<td>What time did you get up?</td>
<td></td>
</tr>
<tr>
<td>Would you describe this as a typical night?</td>
<td></td>
</tr>
</tbody>
</table>

**How would you rate your quality of sleep?**

1  2  3  4  5  6  7  8  9

Best sleep ever   Worst sleep ever

- Sleep and nap diaries
- Pittsburgh sleep quality index

**PSQI score 0-21**

**PSQI score > 5 = sleep problem**
Actigraphy
- actiwatch, AWL

monitors motor activity and light exposure

AWL
- wrist
- neck
Mood, alertness & sleepiness

9-point scales:
1 Very Alert
Very Cheerful
Very Calm
Very Miserable
Very Tense
Very Depressed
9 Very Sleepy
Very Miserable
Very Tense
Very Elated

Karolinska sleepiness scale (KSS)

Community study 3 x daily

Care home study weekly (4 times/day)
Community study

Baseline

Week

Light exposure A or B

Week

Washout period

Week

Light exposure A or B

Week

Washout period

Week

1 week

2 week

3 week

4 week

5 week

6 week

7 week

8 week

9 week

10 week

11 week

Blue: Light exposure A or B

Yellow: Light exposure A or B
Community study

36 participants
60+ years, sleep problems

<table>
<thead>
<tr>
<th>Group</th>
<th>Low intensity</th>
<th>High intensity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of participants</td>
<td>15</td>
<td>21</td>
</tr>
<tr>
<td>Age (years; mean ± SD)</td>
<td>65 ± 4</td>
<td>67 ± 5</td>
</tr>
<tr>
<td>Gender (female, male)</td>
<td>9, 6</td>
<td>16, 5</td>
</tr>
<tr>
<td>PSQI</td>
<td>13 ± 2</td>
<td>12 ± 3</td>
</tr>
<tr>
<td>Light intensity (lux)</td>
<td>400</td>
<td>1100</td>
</tr>
</tbody>
</table>

33 participants analysed
Results

Low vs high intensity light

Low intensity light significantly
- reduced actigraphic nocturnal awakenings
- reduced sleep fragmentation
- increased sleep efficiency

compared to high intensity light
Results  Blue-enriched vs control light

Blue-enriched light significantly

- delayed subjective time trying to sleep
- delayed actigraphic sleep onset time

compared to control light
Poster no. 12

Effects of blue-enriched and control white light (low and high intensity) on sleep, activity, mood and alertness in older people.

Lederle KA, Middleton B, Sletten T.L., Revell V.L. and Skene D.J.
Community study - Conclusions

• Some effects of light on sleep and activity
• Few differences between the lights
• No changes in mood and alertness
Community study - Conclusions

• Insufficient strength of the light signal (intensity, duration)

• Confounding effects of a real world-life environment (outdoor light exposure, social commitments)

• Determine the ideal light conditions for community dwellers with sleep problems (intensity, duration, spectral composition, timing)
Care home study - protocol

Weeks

1 2 3 4 5 6 7 8 9 10 11 12

Weeks

1 2 3 4 5 6 7 8 9 10 11 12

base line care home lights ~ 60 lux

17000 K light ~ 1000 lux

4000 K light ~ 200 lux

wash out period care home lights ~ 60 lux
Participant demographics

80 residents - 69 females, 11 males
Mean age - 85.8 ± 7.5 years, range 59-99 years

<table>
<thead>
<tr>
<th>Care home</th>
<th>Number</th>
<th>Mean age (±SD)</th>
<th>Male: Female</th>
</tr>
</thead>
<tbody>
<tr>
<td>CH1</td>
<td>11</td>
<td>84.9 (6.0)</td>
<td>1 : 10</td>
</tr>
<tr>
<td>CH2</td>
<td>9</td>
<td>84.6 (3.3)</td>
<td>2 : 7</td>
</tr>
<tr>
<td>CH4</td>
<td>13</td>
<td>87.6 (5.9)</td>
<td>0 : 13</td>
</tr>
<tr>
<td>CH5</td>
<td>19</td>
<td>84.1 (7.2)</td>
<td>5 : 14</td>
</tr>
<tr>
<td>CH6</td>
<td>10</td>
<td>87.2 (4.5)</td>
<td>0 : 10</td>
</tr>
<tr>
<td>CH7</td>
<td>7</td>
<td>85.4 (7.5)</td>
<td>1 : 6</td>
</tr>
<tr>
<td>CH8</td>
<td>11</td>
<td>87.4 (11.3)</td>
<td>2 : 9</td>
</tr>
</tbody>
</table>
Light monitoring methods

**Light environment monitoring**

- Weekly - lux meter
- Continuous - Hobo data loggers in each room
- 7 care homes, 20 communal rooms
Care room original light conditions

Dimly lit, not uniform
59 ± 52 lux (mean ± SD, n = 20 rooms)

Indoor lighting measured weekly (lux meter), after sunset
Supplementing light in care homes

Care home 1, 4000 K lights
Care home 8, 17000 K light

More uniform, higher light levels

<table>
<thead>
<tr>
<th>Temperature (K)</th>
<th>Lux</th>
</tr>
</thead>
<tbody>
<tr>
<td>4000 K</td>
<td>195 ± 31 lux</td>
</tr>
<tr>
<td>17000 K</td>
<td>894 ± 129 lux</td>
</tr>
<tr>
<td>Care home 59</td>
<td>59 ± 52 lux</td>
</tr>
</tbody>
</table>

Care home 59 ± 52 lux
24 hour light profiles

17000 K vs washout

4000 K vs washout
Daytime lux levels
Care home 4, 08:00 – 20:00 h

North facing across room

Weeks
Light level (lux)

Baseline
17000 K lights
Washout lights
4000 K lights

Weeks
Light monitoring methods

Light environment monitoring

- Weekly - lux meter
- Continuous - Hobo data loggers in each room
- 7 care homes, 20 communal rooms

Individual light exposure

- Actiwatch - individual light exposure and rest/activity rhythms
Blue-enriched white 17000 K lights
Residents spend more time in brighter light

mins above 500 lux

**CH1**

<table>
<thead>
<tr>
<th>Light condition</th>
<th>4K</th>
<th>WO</th>
<th>17K</th>
</tr>
</thead>
<tbody>
<tr>
<td>Autumn</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Winter</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**CH2**

<table>
<thead>
<tr>
<th>Light condition</th>
<th>17K</th>
<th>WO</th>
<th>4K</th>
</tr>
</thead>
<tbody>
<tr>
<td>Autumn</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Winter</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* p<0.05 17K compared to WO and 4K

mins above 500 lux

**CH5**

<table>
<thead>
<tr>
<th>Light condition</th>
<th>17K</th>
<th>WO</th>
<th>4K</th>
</tr>
</thead>
<tbody>
<tr>
<td>Autumn</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Winter</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*** p<0.0001, 17K compared to WO and 4K

**CH6**

<table>
<thead>
<tr>
<th>Light condition</th>
<th>4K</th>
<th>WO</th>
<th>17K</th>
</tr>
</thead>
<tbody>
<tr>
<td>Autumn</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Winter</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*** p<0.0001, 17K compared to WO and 4K
Posters - P. Lloyd Morgan

Poster no. 14

Supplementing environmental light in care homes.

Poster no. 15

Monitoring environmental light in care homes.
Questionnaire protocol

Scales used:
- Geriatric depression scale (GDS)
- Pittsburgh sleep quality index (PSQI)
- Light acceptability and side-effects
Poster no. 13

Effects of ‘blue-enriched’ and control white light on self-rated depression and sleep in older people living in care homes.

Hopkins S., Morgan PL., Skene D.J. and Middleton B.

Poster no. 16

Effects of ‘blue-enriched’ and control white light on activity levels and timing in older people living in care homes.

Middleton B., Hopkins S., Morgan PL., Barrett D., Schlangen L.J.M. and Skene D.J.
Conclusions

Preliminary analysis

Low, variable lighting levels

Light supplementation
- higher, more uniform, lighting
- increased exposure to brighter light
- no deterioration of mood or sleep
- no significant adverse effects of lighting
To be continued........
Acknowledgements

Katharina Lederle
Dr Tracey Sletten
Dr Vikki Revell

Dr Benita Middleton
Dan Barrett

Dr Samantha Hopkins
Lloyd Morgan
Dr Rebekah Luff

All of our volunteers

Staff at the care homes

Dr Luc Schlangen, Philips Lighting